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# Cost/Benefit Analysis of Marine Corps Range Scheduling Systems

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This report presents a cost and benefit analysis of two range scheduling systems: the Land Use Management System (LUMS), operational at Camp LeJeune, NC, and the Range Facilities Management Support System (RFMSS), operational at Camp Pendleton, CA. On the basis of lesser costs and greater benefits, RFMSS is recommended as the Marine Corps range scheduling system.

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## FOREWORD

This cost and benefit analysis of two range scheduling systems was conducted for the Marine Corps Combat Development Command and funded under N66001-89-D-0151-7J01. Since completion of this study, an economical graphics capability for the Range Facilities Management Support System (RFMSS) has become available and the decision to implement RFMSS throughout the Marine Corps is pending.

Dr. Patrick H. McCann was the contracting officer's technical representative.

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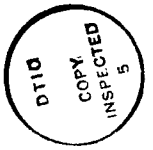

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# EXECUTIVE SUMMARY

This analysis presents Marine Corps decision makers with an orderly and meaningful display of the costs and benefits associated with two range scheduling systems: the Land Use Management System (LUMS), operational at Camp Lejeune, North Carolina; and the Range Facilities Management Support System (RFMSS), operational at Camp Pendleton, California.

LUMS and RFMSS are very different systems. LUMS was designed as a multi-use, all-encompassing land use management system, including environmental planning and assessment, in addition to range management features. This system has an integral Geographic Information System (GIS) capable of cataloging and displaying data on natural and man-made features and boundaries, vegetation, fish and wildlife habitats, types of soils, weather patterns, and archeological items of interest. Because of this large GIS and the ability to display this data in map format, LUMS is supported on a mini-computer. On the other hand, RFMSS was designed specifically for range management and for limited support of program and budget actions associated with range support. It has no GIS capability. RFMSS runs on a network of PCs (personal computers).

LUMS is more expensive than RFMSS. When the present value (using a 10% discount rate) of system procurement, maintenance, and personnel costs is considered over a twelve-year period, LUMS costs more than five times as much as RFMSS. To implement a range scheduling system at seven designated sites would require a present value investment of $2.7 million for LUMS as compared to $533 thousand for RFMSS.

RFMSS is the more beneficial system. When 26 primary criteria for evaluating range management systems are considered, RFMSS lacks capability on only four of those criteria while LUMS lacks capability on seven. When the relative weights of these criteria are taken into account, RFMSS is nearly one and one-half times more effective than LUMS.

When costs and benefits are combined, RFMSS is more than seven times as effective as LUMS. The selection of RFMSS as the most effective system is insensitive to major changes. Even if LUMS could be enhanced with all capabilities that it lacks at no cost, RFMSS would still be more effective from a cost/benefit perspective. In order for the two systems to be relatively equal in effectiveness as measured by cost/benefit ratios, the GIS feature of LUMS would have to be considered two and one-half times more important than all other features combined.

Based on this analysis, there are two recommendations:

- RFMSS should be selected as the Marine Corps Range Scheduling System. This recommendation is based on the lesser costs and greater benefits of RFMSS.

- A comprehensive site analysis should be conducted at each of the six sites that are scheduled to receive a range scheduling system. This analysis is needed to determine precisely what the total costs are to implement RFMSS at these sites.

# I. INTRODUCTION

This reports presents the results of a cost/benefit analysis that was done to assist Marine Corps Combat Development Command (MCCDC) decision makers in selecting an automated range scheduling system as the standard for use at U.S. Marine Corps (USMC) bases and air stations. The basis for the benefit comparison is 26 criteria that were supplied by the USMC as relevant to range scheduling capabilities. The cost comparisons are based on the hardware, software, personnel, and maintenance costs required over a 12-year operating time frame.

There are currently two automated range scheduling systems being used at two Marine Corps bases that are contenders for the standard USMC system. These two are: 1)the LUMS (Land Use Management System), and 2)the RFMSS (Range Facilities Management Support System). Thus the cost/benefit analysis in this report compares LUMS to RFMSS. The results of the analysis lead to a recommendation on which system should be selected as the standard range scheduling system.

# II. BACKGROUND

Military training ranges are used for a broad set of activities that ultimately boil down to units employing military equipment in a practice setting. Such practice is used to attain or maintain proficiency and/or develop or sharpen tactics. Training ranges require a minimum area of land, sea and/or air space for the activity being conducted.

Training can impact the local environment, perhaps unfavorably, depending on the kind and nature of training activities taking place. Training ranges supporting live-fire have to be carefully controlled to ensure the firing of live ammunition is done safely and efficiently.

Range Utilization and Management Systems. The system that is used by the local range scheduling office to control training ranges is at the heart of managing many of the issues associated

with range use and the conduct of safe, efficient training. The minimal range utilization system should support the following functions:

- Allocating a training range with sufficient space and other characteristics to accomplish the intended training.
- Ensuring that activities in different range areas do not conflict with one another (e.g., rounds from one range are not planned to impact in another occupied range).
- Accommodating schedule/range changes, adjustments, and cancellations.
- Monitoring range status and utilization.
- Preparing required notices and warnings of range activities to affected agencies.
- Providing statistics on training conducted, people trained, weapons/ammunition fired, range utilization, etc.

Because of two other important considerations -- environmental impact/management and range maintenance support -- the minimal range utilization system can be enhanced to deal with a variety of issues other than simply range area scheduling. In support of environmental issues, the range utilization system, for example, could provide the capability to assess whether or not a given activity is environmentally possible (or unacceptably damaging). Range maintenance functions can be accommodated within a range utilization system by appropriate analysis of utilization that leads to upkeep or repair of natural or man-made features, or collection of expended or unexpended ordnance. Thus, in addition to the minimal functions, a more robust range utilization system could support all of the following functions:

- Scheduling and utilization,
- Environmental assessment and management,
- Maintenance support and funding planning.

In this case, the range utilization system would more appropriately be termed a "range management system."

Geographic Information System (GIS) Support. Although each of the functions of this hypothetical range management system

is geographically oriented, the major function of environmental assessment and management requires a geographic information system (GIS) of considerable complexity and scope. (Conceivably, the scheduling and utilization function, maintenance support, and funding does not require that a GIS be used.) Capabilities of the GIS include data on and display of natural and man-made features and boundaries, vegetation, fish and wildlife habitats, types of soil, weather patterns, archeological items of interest, and other capabilities required for specific locations. The breadth of application requirements from what could be a rather simple range scheduling system to a fully capable range (land, air, sea) management system will have significant impact on the costs and benefits of competing systems that provide a range scheduling capability.

## III. ALTERNATIVES

The Marine Corps currently has two operational range scheduling systems that also perform, to greater or lesser degree, other functions associated with range and environmental management. The systems are the LUMS and RFMSS.

From available descriptive documentation, the LUMS and RFMSS systems seemed to have emerged from two separate ends of the range utilization spectrum. In fact, the names themselves are instructive. The LUMS (Land Use Management System) is intended to have all-encompassing land use management capabilities, including environmental planning and assessment, while RFMSS (Range Facility Management Support System) is more concerned with range scheduling, operation, and maintenance. This is not to imply that one approach is more "right" than the other. Since LUMS is intended to be a comprehensive system, it is built on sophisticated GIS capabilities. RFMSS, on the other hand, has no GIS capabilities other than those that are incidental to the scheduling of defined areas of land and air space. A review of available specifications and descriptive literature on LUMS and RFMSS was made to determine, in general, what their foundations were as range scheduling systems.

LUMS. The LUMS was built by Environmental Systems Research Institute, Inc., for Headquarters, United States Marine Corps (HQMC) to satisfy three requirements.

1. The first requirement provides "environmental macros" for conducting environmental assessments.
2. The second requirement is a GIS that is the foundation for the environmental assessment capabilities. This GIS is known as ARC/INFO, a proprietary product built on the commercially available INFO relational database management system (RDBMS).
3. The third requirement is a range scheduling system.

The range scheduling system is made up of three smaller, independent subsystems. A brief description of each follows:

a. The Request Subsystem.
This subsystem will be used by remote users. These users will be able to make Training Area requests and get reports on their status. They will also be able to cancel or change their requests, create Action Taken reports, and get information about training areas.

b. The Scheduling Subsystem.
This subsystem allows the Range Control Officer (RCO) to process and review requests and cancellations. The RCO may also create Firing Notices, Notices to Airmen, and the Daily Firing Card. All options of the Request Subsystem may also be used from the Scheduling Subsystem.

c. The Utilization Subsystem.
This subsystem will be used by the RCO to create reports based on actual firing range and training area usage. They will also be able to purge data that have become outdated.

Because a fundamental capability of LUMS is the ARC/INFO GIS, the hardware support requirements have to be sufficient to handle a large geographic information database. At the time

the system was designed (1987), a PRIME minicomputer was chosen as the host hardware for the system. The system has been implemented at Camp Lejeune, North Carolina. Users are connected via terminals from the central computer site.

Since LUMS has a database that precisely captures the location, dimensions, etc., of all of the training areas managed at Camp Lejeune, the range scheduling subsystem is an adjunct to the GIS information subsystem. There is no intent for any one USMC office at Camp Lejeune to be capable of using all LUMS functions concurrently. The range scheduling subsystem is a distinct entity within LUMS and requires no scheduling office interface with either the environmental macros or ARC/INFO.

RFMSS. The RFMSS is sponsored by the US Army Corps of Engineers Construction Engineering Research Laboratory (CERL). Its primary purpose is to support Army base functions in managing training range facilities. The RFMSS is a collection of microcomputer-based programs. RFMSS is currently being provided at no cost to authorized users. The system is currently being used at many Army installations as well as at Camp Pendleton.

RFMSS has eight modules:

a. Setup. Installations can customize RFMSS to suit their particular set of training facilities and operations. The Setup program steps the user through establishing a list of training facilities, range conflicts, training units, and a host of other information.

b. Schedule. Scheduling is done through the second module of RFMSS. A spreadsheet interface allows the user to view up to 20 areas for 14 days on the screen. Multiple units are shown on the screen and function keys are used to drive most actions. Up to 800 facilities may be scheduled on a daily basis for up to 25 units each day. Schedule supports other modules of RFMSS through data exchange and processing of many types of data.

c. Remote. Computer access to the schedule information is possible through this module. Range offices can set up access for units to identify potential training resources and submit reservations for ranges. Electronic mail messages are supported.

d. Bulletin. Requests entered through Schedule or Remote can be listed to a printer in a variety of formats using this program module. Lists of range schedules sorted by date, range, unit, or any other data field are available.

e. COMMO. This automates the firing desk or radio room activities of collecting and analyzing range usage information. Direct access to the schedule allows the radio operator to review what activities have been scheduled and directly enter operations data.

f. Utilize. Data collected by the COMMO program can be used to support utilization, analysis, and reporting. Comparison of scheduled and actual activities for each range, each unit, or commands is supported.

h. RPMADATA. The Range Control Office can collect a limited amount of range operations maintenance data using RFMSS. Data for man-hours worked and expenses incurred can be collected for each range. Reports to identify where costs are incurred are provided.

i. IRFSS. IRFSS is used to collect data on ranges. IRFSS has two distinct parts. The first part provides an overview of the installation from a training perspective. The second part is an individual range and training area overview.

RFMSS evolved from a Version 1 scheduling program to the current Version 2 that provides additional tools for managing range operations. Version 2.2 with all eight modules described above will be delivered with full documentation on 30 September 1990. The support for RFMSS in the networked version

requires an IBM/compatible 386 file server, XT workstations, XT/AT remote access terminals, and compatible network software. In contrast with LUMS, which uses the INFO RDBMS to handle the LUMS DBMS functions, RFMSS uses R:BASE for DBMS functions.

Major Points of Difference. The major points of difference between LUMS and RFMSS are three: 1) hardware/software, 2) GIS capabilities, and 3) continuing support and development.

Hardware/Software. The LUMS operates on a PRIME minicomputer using proprietary software, ARC/INFO, as the primary tool. Remote access is handled through terminals that are connected to the central site. RFMSS operates on networked IBM-compatible personal computers (PCs) with a 386 server and XT/AT class machines used as work stations for remote access. Commercial software is used for networking (Bayan Vines) and for data management (R:BASE for DOS).

GIS Capabilities. LUMS has extensive, comprehensive GIS capabilities that can be used for analyses and planning that require a wide range of geographic information in both map and tabular form. RFMSS has no capabilities that can be considered a GIS. One reference suggests that RFMSS may be interfaced with GRASS (Geographic Resources Analysis Support System), a GIS available to government users without cost. However, GRASS is written in UNIX and cannot be easily or inexpensively interfaced with RFMSS.

Continuing Support and Development. The LUMS appears to be a reasonably mature system whose primary changes may evolve toward the GIS capability rather than the range scheduling capability. Given the proprietary nature of ARC/INFO, continued contract support for LUMS GIS development may be required, although it may not be required for the scheduling subsystem. RFMSS development will apparently be supported by CERL until 1992, at which time users may be required to provide support resources. As stated earlier, RFMSS Version 2.2 is to be delivered with full documentation on 30 September 1990.

# IV. OBJECTIVE

The objective of this analysis is to present Marine Corps decision makers with an orderly and meaningful display of the costs and benefits for two range scheduling systems: the Land Use Management System (LUMS), operational at Camp Lejeune, North Carolina; and the Range Facilities Management Support System (RFMSS), operational at Camp Pendleton, California. The two systems are evaluated as to which is best qualified to meet the following 25 criteria established by the United States Marine Corps:

- Deconflict training areas.
- Deconflict land and airspace use.
- Display current status of range i.e. empty, occupied live-fire, non live-fire, overflight live-fire, overflight non live-fire.
- Display unit status on range, i.e. non live-fire and live-fire.
- Provide for changes to data or blocks of data.
- Print a range training area schedule.
- Compute and print the airspace release.
- Print special notes and instructions related to range, training, or airspace use entrees.
- Display in color graphics a range use map showing maneuver, air, live-fire, and maintenance areas.
- Allow for flexibility in range designations and subdivision of training areas.
- Provide for changes to range boundaries and subdivisions.
- Maintain data for reports, by unit, training area, weapon system, type ordnance, type training, amount requested versus amount used, and airspace released to the FAA by the time of day and altitude.
- Prepare message responses to message-type range requests.
- Prepare message range schedule and airspace releases.
- Check to ensure that the weapons system and ordnance are authorized on the range requested.

- Locate ranges or airspace for units to train in (the scheduler or unit would enter some of the parameters of the request i.e. dates, times, type of training, amount of airspace required.) The system would locate an area for the unit to train within the parameters of the request.
- Schedule training devices.
- Maintain a database of qualified range safety officers.
- Schedule frequently used sets of ranges as a set or group.
- Allow the local range management office to act as the master scheduling authority receiving, consolidating, deconflicting and issuing range requests from multiple users via desktop terminals.
- Allow the master station to interface with another master station for range information via modem.
- Maintain data log for arrival/departure times, weapons used, ordnance type/amount used, number of personnel, number/type of equipment, altitude used.
- Allow for ready back-up of schedule data for access and retrieval in the event of primary media storage system failure.
- Provide for manual scheduling operation in the event of primary system failure.
- Provide for ready update of database following periods of manual operation because of primary system failure.

In the initial meetings with the Marine Corps Combat Development Command (MCCDC) personnel a 26th criterion was added.

- Provide for user-friendly operation.

Secondary considerations in the evaluation are: interface of the system and the Land and Training Area Requirements Management Information System (LATAR MIS) and the interface of the system and LATAR MIS with the Concepts, Doctrine, and Training (CONDOCTR) information system umbrella.

Systems are to be analyzed over a 12-year economic life.

# V. GENERAL APPROACH

The general approach used to analyze the two systems was to perform an initial assessment from available documentation, visit operational sites to interview range control personnel, observe LUMS and RFMSS in operation to evaluate systems benefits, and perform a formal cost/benefit analysis. Details are provided in sections VII through IX.

## A. INITIAL ASSESSMENT

An initial assessment was conducted by contacting the LUMS and RFMSS program managers. These program managers provided a system overview, orientation, and related literature. A thorough literature review of the reference material listed in Appendix A was conducted.

In preparation for site visits, the evaluation criteria were grouped by the following categories based on the range scheduling system function they supported.

- Allocation and scheduling
- Messages, reports, and status information.
- Software/hardware considerations.
- Ancillary databases and functions.

In order to ascertain the degree to which a system fulfilled the specified criteria, a Likert Scale was integrated into a questionnaire used for interview purposes. This questionnaire is shown in Appendix B.

## B. DETERMINING SYSTEM BENEFITS

To analyze the benefits of each system, operational sites were visited. A LUMS demonstration was viewed at Camp Lejeune and range control personnel were interviewed as on their view of system benefits using the previously developed questionnaire. The same procedure was followed for RFMSS by a site visit to Camp Pendleton. To confirm the results obtained from these site visits and collect other related information, the LUMS and RFMSS program managers were visited once again. (Twenty-

nine Palms was also visited, where RFMSS is only partially operational.)

An analysis of the evaluation criteria revealed that at least one of the systems failed on 13 of the initial 26 criteria. Further analysis centered on these failed criteria. Marine Corps Combat Development Center personnel were contacted to rank order and weight these thirteen criteria. A weighting scheme was constructed to evaluate the differential benefit of each of the two systems.

## C. DETERMINING SYSTEM COSTS

Hardware and software costs were calculated partly from data supplied by the LUMS and RFMSS program managers and partly from General Services Administration (GSA) schedules for commercially available hardware and software. Hardware and software costs for RFMSS were based on the configuration at Camp Pendleton and for LUMS on the configuration at Camp Lejeune. Costs for hardware and software maintenance, training, personnel, and utilities were also considered. These costs were included in the total cost calculations only when a cost difference between the two systems could be clearly identified.

Costs were then allocated over the twelve-year life cycle. The discounted cost (present value) of each system was then computed based on the standard Department of Defense 10% discount rate.

## D. COST/BENEFIT ANALYSIS

To determine the best system, cost/benefit ratios were computed. Additionally, a sensitivity analysis was conducted to determine what changes would be required in order for both systems to have equivalent cost/benefit ratios.

## VI. ASSUMPTIONS

The following assumptions were made in calculating the costs of either range scheduling system.

a. The selected system would be placed in operation at the following sites.

Marine Corps Base, Camp Pendleton, CA
Marine Corps Base, Camp Lejeune, NC
Marine Corps Base, Quantico, VA
Marine Corps Base, Camp Butler, Okinawa, Japan
Marine Corps Air Station, Yuma, AZ
Marine Corps Air Station, Cherry Point, NC
Marine Corps Air-Ground Combat Center, Twentynine Palms, CA

b. Since RFMSS is operational at Camp Pendleton and LUMS is operational at Camp Lejeune, the selected system would only have to be extended to six sites.

c. If RFMSS is selected, the cost of the extension recognizes that RFMSS is partially operational at Twentynine Palms.

d. The selected system will be extended to all seven sites in Fiscal Year 1991.

## VII. COST COMPARISON

This section provides a cost comparison between the LUMS and RFMSS hardware and software installations. For both RFMSS and LUMS, the range management software has been developed and will be provided to each site without cost. However, hardware costs will be incurred at each site to run the range management software. The costs represent a "generic" system in that they reflect the configuration of the current systems installed and in operation at USMC bases. It is recognized that the installation of either system at the planned additional six sites would require slight modifications to the list

of associated hardware due to differences in range configuration and mission. For example, certain installations may require more than six workstations, while others may require less than the current six stations. Costs may also vary to some degree from the single-site cost if the hardware and software were procured in bulk for the entire USMC range scheduling requirements. However, neither of these factors will have any influence on the outcome of the cost benefit analysis because of the large difference in cost between the LUMS and RFMSS "generic" systems. The following provides the detailed breakdown of the costs for each system.

Remote Users For both systems, costs for remote users were excluded. For each remote user, a terminal or PC and the appropriate modem will be required. The number of remote users will vary widely from site to site; however, the number of remote users at each specific site should be the same regardless of whether LUMS or RFMSS is selected. Additionally, these costs would be mitigated if the remote user already has a PC that may be used. Within these constraints, the cost for hardware and modems for remote users at each site should be about the same regardless of the selected system.

LUMS The costs for the LUMS installation were received from Mr. Marlo Acock, the Program Manager for Land Use/Real Estate Installations/Logistics assigned to HQMC. In this capacity, Mr. Acock serves as the LUMS Program Manager. The LUMS operates on a Prime-2755 mini-computer and the generic configuration described in Table 1 reflects the current installation at Camp Lejeune as confirmed through a visit to the site and a demonstration of the system. With the assistance of the LUMS Project Manager, the costs shown in Table 1 have been identified for each site installation. The last cost shown in Table 1 reflects system design, development and documentation which is a "sunk" cost that does not have to be incurred for each new site installation. The Database Construction cost has been estimated by using the cost for the entire LUMS database and extracting the cost associated with the range scheduling portion. However, it should be noted that a unique database must be constructed for each site installation. The original costs for Database Construction at Camp Lejeune, was $145,000 for the entire land use system. The range related portion was estimated to be 10% of that amount; this estimate was confirmed by the LUMS project manager.

LUMS SINGLE-SITE INSTALLATION COSTS

| Item | Unit Price | Quantity | Total |
|---|---|---|---|
| PRIME CPU | $ 90,350 | (1) | $ 90,350 |
| System Console | NSP | (1) | NSP |
| Disk Drive | NSP | (1) | NSP |
| Disk Control Unit | NSP | (1) | NSP |
| Tape Drive | 27,500 | (1) | 27,500 |
| Tape Control Unit | NSP | (1) | NSP |
| System Printer | 9,000 | (1) | 9,000 |
| Station Printer | 2,500 | (1) | 2,500 |
| Color Printer | 550 | (0) | * |
| Mono Monitor/ Terminal | 995 | (1) | 995 |
| Color Monitor/ Terminal | 7,495 | (1) | 7,495 |
| Digitizing Pad | 10,138 | (0) | * |
| Pen Plotter | 13,900 | (0) | * |
| Modem | 1,880 | (2) | 3,760 |
| Geo Info System | 68,500 | (1) | 68,500 |
| Database Construction | 14,500 | (1) | $ 14,500 |
| Custom Macro Package | $191,264 | (1) | ** |
| | | Total | $224,600 |

* Item not required for Range Scheduling capability of LUMS

** Sunk cost in system development

Table 1
LUMS Single-Site Installation Costs

The annual operating costs per site installation have been estimated by the Program Manager to include a GS-9 level Programmer/Analyst to provide operation of the PRIME computer and database administration of the GIS database. The annual cost of this individual is $27,177 using current GS pay scales (GS-9, Step 4). In addition, the Program Manager estimates that the average cost per year/per site for hardware and software maintenance will equal $5500.

As described earlier, LUMS was designed as a multi-use system supporting not only range management but total installation land use management. LUMS was included in the HQMC five year plan but was not funded in the most recent round of cuts. Consequently, costs associated with installing LUMS at each base must be allocated to range management since no other source for shared funding presently exists.

RFMSS The costs for the RFMSS were based on the estimate of a generic single-site equipment and software configuration provided by Mr. Thomas Mahon, the RFMSS Program Manager assigned to the Army Corps of Engineers Construction Engineering Research Laboratory (CERL). As with the LUMS equipment and software, the RFMSS installation was similar in nature to the systems currently installed at Camp Pendleton and Twentynine Palms as confirmed by visits to both sites as well as a demonstration of both systems. The costs were obtained through current GSA Schedule listings, where possible, and from current local retail sources in a few cases where the hardware or software was not listed in the current GSA Schedule. The prices quoted are considered a "worst case". Lower prices are achievable both from shopping with commercial vendors and through a bulk buy for the entire six-site range installation requirements. RFMSS costs are shown in Table 2.

The RFMSS Program Manager provided an estimate of the annual software maintenance cost for the entire seven USMC range sites (one operating and six expansion sites) at $50,000 per year. To allow for a comparison with LUMS, this cost has been divided by seven (the number of sites) to equal $7,143 per site per year. The equipment maintenance costs equal about $2000 per year for a single site based on current GSA Schedule maintenance costs for personal computer systems. There is no requirement for an on-site operator and database administrator since their functions would be accomplished by the local Range Scheduling office.

Training Costs In review of both systems with the respective program managers, it was revealed that both systems have been designed to be user friendly with a built-in menu capability. As a result, neither system requires that operating personnel be formally educated in computer operations or receive extensive training. It has been estimated that for the normal range scheduling operations, the operating personnel can be trained

RFMSS SINGLE-SITE INSTALLATION COSTS

| Item | Unit Price | Quantity | Total |
|---|---|---|---|
| System Server | | | |
| COMPAQ Desk Pro 386/20E | | | |
| 1 Mb Ram | | | |
| 130Mb Hard Drive | | | |
| Color Monitor | | | |
| MS DOS 3.3 | $ 4,969 | (1) | $ 4,969 |
| Work Stations | | | |
| ZENITH 248 Advance Sys | | | |
| 1 Mb Ram | | | |
| 40 Mb Hard Drive | | | |
| Color Monitor | 2,150 | (6) | 12,900 |
| Modems | | | |
| HAYES 2400 | 372 | (5) | 1,860 |
| Network | | | |
| ETHERNET Card | 362 | (1) | 362 |
| Tape Backup | | | |
| EMERALD Sys | 1,028 | (1) | 1,028 |
| Printer | | | |
| OKIDATA Dot/Mat | 400 | (1) | 400 |
| Software | | | |
| Banyan Vines | 1,184 | (1) | 1,184 |
| ETHERNET | 625 | (1) | 625 |
| RBase for DOS 2.11 | 643 | (1) | 643 |
| PC Anywhere | 135 | (1) | 135 |
| Misc-Cables/Connectors | $ 500 | (1) | $ 500 |
| | | Total | $24,606 |

Table 2
RFMSS Single-Site Installation Costs

in a one-week period. Further, this training should be oriented towards on-the-job, hands-on training using the computer terminal rather than formal classroom instruction. The description of training requirements provided by both program managers was confirmed in visits to the sites through observation of the systems being exercised throughout their operating capabilities.

As a result of the similar training requirements for both systems, there was no reason to obtain training cost data for either system. The training costs for this analysis were considered about equal and, therefore, had no impact on the outcome of the analysis.

Personnel Costs As outlined above, the LUMS does require a trained programmer/analyst at each site to perform hardware and software operation and database administration. This individual has been identified by the LUMS Program Manager as a GS-9 level Programmer/Analyst. RFMSS does not require a similar person to perform these functions. The remainder of the personnel required are range scheduling and administrative personnel. Both systems will require identical numbers of personnel of equal qualifications and grade level to perform range scheduling and administration functions. RFMSS at Camp Pendleton and LUMS at Camp Lejeune were installed and are now operational without any increase in range control personnel.

Utility and Facility Requirements

Utilities While the determination of specific utility requirements for either LUMS or RFMSS is beyond the scope of this study, a discussion of the general requirements is considered germane.

COST COMPARISON: SINGLE-SITE INSTALLATION AND FIRST YEAR OPERATING COSTS

| | LUMS | RFMSS |
|---|---|---|
| System | $224,600 | $24,606 |
| Maintenance | 5,500 | 9,143 |
| Operator/Data Base Administrator | 27,177 | - |
| Total= | $257,277 | $33,829 |

Table 3
Cost Comparison: Single-Site Installation and First Year Operating Costs

The LUMS Site Preparation Plan dated September 18, 1987 provides specific guidance for the electrical requirements for the LUMS. These specifications provide rigid criteria which should be followed in the installation of LUMS. These specifications are tailored to the installation of a mini-computer. While the specifications most likely exceed those required for the installation of the RFMSS which is a PC based system, the fact remains that both systems require a high quality electrical distribution system. Such a system must be free of disruptive "electrical" noise impulses, ground loops and other interference.

Further, the use of modems also requires quality phone lines capable of transmitting information from station to station. Experience thus far has shown that without such dedicated lines the system will experience problems in both the quality of transmission and the speed in which data are transmitted. According to people interviewed at Camp Pendleton, these problems existed with the installation of RFMSS.

There will be a cost associated with meeting these requirements for future installations regardless of the system chosen. While this cost has not been considered a part of the analysis reported herein, it is recommended that further site-by-site study be conducted of all range utility requirements as part of the plan for range scheduling system expansion.

Facilities The LUMS installation does require a well-ventilated space for the computer installation and slightly more room than a RFMSS installation simply due to the size of the central processing unit and peripheral equipment. Beyond that, no additional facilities are required to install either LUMS or RFMSS. All facilities planned for installation of a range scheduling system currently have a range scheduling office which should be able to accommodate most of the terminals and associated equipment. It is recommended that study be conducted of each facility scheduled to receive a scheduling system which outlines specific requirements of each facility.

Life Cycle Costs Table 4 shows the life cycle costs for single installations of both LUMS and RFMSS. As shown, the first year costs represent hardware and software initial purchase as well as maintenance and personnel costs. Costs shown for years 2 through 12 are associated with maintenance and personnel only. The present value of each system was computed using the Department of Defense (DoD) established 10% discount rate and applied using the mid-year convention factor that considers each year's costs to be realized in the middle of the year.

SUMMARY. In the foregoing paragraphs an estimate of the costs to procure, operate, and maintain both systems has been provided. For system hardware and software costs alone, LUMS is more than nine times as costly as RFMSS. When the present value of system procurement, maintenance, and personnel costs is considered, LUMS is more than five times more costly than RFMSS. If each of the systems were expanded to six additional sites as currently planned, the total cost to the Marine Corps in terms of present value over the twelve-year period would be approximately $2.7 million for LUMS as compared to $533 thousand for RFMSS.* From a cost point of view alone, LUMS is a far more costly system then RFMSS.

* Note -- The total costs do not include costs required for utilities, facilities, personnel training, and remote user terminals or PCs and modems.

| LIFE CYCLE COST PRESENT VALUE | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | TOTAL |
| Present Value Factor | .954 | .867 | .788 | .717 | .652 | .592 | .538 | .489 | .445 | .405 | .368 | .334 | |
| LUMS Cost | 257,277 | 32,667 | 32,667 | 32,667 | 32,667 | 32,667 | 32,667 | 32,667 | 32,667 | 32,667 | 32,667 | 32,667 | |
| LUMS Present Value | 245,442 | 28,322 | 25,742 | 23,422 | 21,299 | 19,339 | 17,575 | 15,974 | 14,537 | 13,230 | 12,021 | 10,911 | 447,814 |
| RFMSS Cost | 33,749 | 9,143 | 9,143 | 9,143 | 9,143 | 9,143 | 9,143 | 9,143 | 9,143 | 9,143 | 9,143 | 9,143 | |
| RFMSS Present Value | 32,197 | 7,927 | 7,205 | 6,556 | 5,961 | 5,413 | 4,919 | 4,471 | 4,069 | 3,703 | 3,365 | 3,054 | 88,840 |

**Table 4**
**Life Cycle Cost Present Value**

# VIII. BENEFIT COMPARISON

In order to compare benefits of the two systems, LUMS and RFMSS, both systems were observed in operation and range control personnel were interviewed in depth. Additionally, the program manager of each system was interviewed. System benefits were judged based on the following 26 criteria identified by the USMC. Criteria are grouped by function.

## ALLOCATION AND SCHEDULING

- Allow the local range management office to act as the master scheduling authority receiving, consolidating, deconflicting and issuing range requests from multiple users via desk top terminals.
- Deconflict training areas.
- Deconflict land and airspace use.
- Allow for flexibility in range designations and subdivision of training areas.
- Provide for changes to range boundaries and subdivisions.
- Check to ensure that the weapon system and ordnance are authorized.
- Locate ranges or airspace for units to train in (the scheduler or unit would enter some of the parameters of the request, i.e., dates, times, type of training, amount of airspace required). The system would locate an areas for the unit to train within the parameters of the request.
- Schedule frequently used sets of ranges as a set or group.

## SOFTWARE/HARDWARE CONSIDERATIONS

- Provide for changes to data or blocks of data.
- Display in color graphics a range use map showing maneuver, air, live-fire, and maintenance areas.
- Allow the master station to interface with another master station for range information via modem.

- Allow for ready back-up of schedule data for access and retrieval in the event of primary media storage system failure.
- Provide for manual scheduling operation in the event of primary system failure.
- Provide for manual scheduling operation because of primary system failure.
- Provide user friendly operation.

## ANCILLARY DATABASES AND FUNCTIONS

- Schedule training devices and simulators.
- Maintain a database of qualified range safety officers.
- Maintain data log for arrival/departure times, weapons used, ordnance type/amount used, number of personnel, number/type of equipment, altitude used.

## MESSAGES, REPORTS, AND STATUS INFORMATION

- Display current status of range, i.e., empty, occupied live-fire, non live-fire, overflight live-fire, overflight non live-fire.
- Display unit status on range, i.e., non live-fire and live-fire.
- Print a range training areas schedule.
- Compute and print the airspace release.
- Print special notes and instructions related to range, training, or airspace use entrees.
- Maintain data for reports by unit, training area, weapons system, type ordnance, type training, amount requested versus amount used, and airspace released to the FAA by the time of day and altitude.
- Prepare message responses to message-type range requests.
- Prepare message range schedule and airspace releases.

## SYSTEM EVALUATIONS

An evaluation of each system relative to the 26 categories is presented below.

**1. Allow the local range management office to act as the master scheduling authority receiving, consolidating, deconflicting, and issuing range requests from multiple users via desk top terminals.**

Both systems perform equally well when judged by this criterion. Remote users may place a request for a range or training area. That range or training area is not scheduled until the range management office approves and processes the request.

LUMS has some edit features not included in RFMSS. The request is computer edited in LUMS for weapon type, unit, and range conflict. If the weapon type is not allowed for the range, if the unit is not on the database, or if the range is already scheduled, the system will reject the request without intervention of range control personnel. Thereby, the workload on LUMS range personnel is reduced by these system edits but flexibility is also reduced.

RFMSS, on the other hand, allows all requests to be processed by range personnel. At Camp Pendleton, where RFMSS is used, some training areas and ranges are large enough to have multiple units using them concurrently. Therefore, since the request is not rejected by the system, ranges and training areas may be more effectively utilized.

**2. Deconflict training areas.**

Both systems deconflict training areas. Both have provisions in initializing the system to identify conflicts. For instance, if range A shoots into range B, then ranges A and B are in conflict. If range A is scheduled, range B may not be occupied. Conversely, if range B is occupied, range A may not go to live fire status. The two systems handle these conflicts differently.

In LUMS, if range A is scheduled, the automatic edit features will reject any request for either range A or B for the time period range A is scheduled. Range control personnel have the option to override the conflicts. The requestor must submit a written request to Range Control requiring override outside of the automated system since the requestor cannot override the edits.

As stated earlier, RFMSS does not use system edits in the same manner. All requests that are properly input will be reviewed by Range Control using the system. If a request is being reviewed, the system will highlight all conflicts. For instance, using the same range A and B example above, if range A has been previously scheduled and Range Control personnel are reviewing a request for range B for the same time period, the fact that there is a conflict with range A will be highlighted by the system. Range Control personnel will then make the decision on whether or not to schedule range B based on the activities of each of the units.

**3. Deconflict land and airspace use.**

Both systems schedule a certain amount of airspace with each range. For instance, if range A is scheduled, a specified amount of airspace is concurrently scheduled. However, at Camp Pendleton and Twentynine Palms, a requirement exists to be able to schedule multiple strata of air space concurrently. Therefore, deconflicting land and airspace use becomes a three-dimensional problem. For instance, a unit may need a training area for maneuver, a helicopter may need to fly over the area in the lower strata of airspace, and jet aircraft may need to overfly the area in the higher strata of airspace.

LUMS does not handle this three dimensional problem. The LUMS system was designed based on scheduling problems at Camp Lejeune and this multiple use of airspace is not a big problem there.

RFMSS handles the three-dimensional problem to a degree. Through a range naming convention, each of the strata of airspace may be named as a separate range, conflicts identified on the system, and then multiple

layers of airspace scheduled. Camp Pendleton has used this system successfully but has limited its use to two strata: the stratum associated with the range and airspace to a certain altitude and a stratum of airspace above that.

4. **Allow for flexibility in range designations and subdivision of training areas.**
5. **Provide for changes to range boundaries and subdivisions.**
6. **Provide for changes to data or blocks of data.**

These three criteria are grouped together since a system's capability to do any one of the three relates to the other two. Both systems handle name change data equally well. For instance, if range Victor was to be subdivided into two smaller ranges Victor-1 and Victor-2, changes could be made very easily to both systems in terms of names.

The big difference on performance of these criteria relates to the Geographic Information System (GIS). Since only LUMS has a GIS, it is the only system which contains internal data on any of the boundaries. Therefore, the subdivision of Victor into Victor-1 and Victor-2 in LUMS can be changed not only in name but also in the internal representation of the boundaries. This change of information on the precise location of the boundaries is not a simple task and requires programmer/analyst support to make the changes.

RFMSS does not have an underlying GIS; therefore, there is no internal representation of boundaries. Consequently, only name changes can be made and the boundaries must be plotted on hard copy maps in the Range Control area.

7. **Check to ensure that the weapon system and ordnance are authorized on the range requested.**

LUMS uses an edit feature to ensure that the weapon is authorized for the range. If a requesting unit attempts to schedule a range for a weapon system that is not authorized, the system will reject the request.

RFMSS will allow Range Control personnel to review the request and this system relies on those personnel to ensure that the weapon system is authorized for the range.

8. **Locate ranges or airspace for units to train in (the scheduler or unit would enter some of the parameters of the request, i.e., dates, times, type of training, amount of airspace required). The system would locate an area for the unit to train within the parameters of the request.**

Neither LUMS nor RFMSS has features which will locate ranges from parameters.

LUMS has a feature which relates to this criterion. One of the menu items allows the remote user to get information on a given range. If the user designates the range, the system will provide a brief description of the range to include description, location (coordinates), weapons authorized, ammunition authorized, and communication instructions.

9. **Schedule frequently used sets of ranges as a set or group.**

Neither system will schedule multiple ranges and areas as a group. RFMSS will incorporate this feature in the delivery version 2.2 to be completed by 30 September 1990; however, this option was not fully developed nor demonstrated at either Camp Pendleton, Twentynine Palms, or CERL.

10. **Display current status of range, i.e., empty, occupied live-fire, non live-fire, overflight live-fire, overflight non live-fire.**

Both systems perform very well when judged by this criterion.

**11. Display unit status on range, i.e., non live-fire and live-fire.**

Both systems perform very well when judged by this criterion.

**12. Print a range training area schedule.**

Both systems perform very well when judged by this criterion.

**13. Compute and print the airspace release.**

Both systems keep track of airspace used. Both systems prepare information for the Notice to Aviators. Neither LUMS at Camp Lejeune nor RFMSS at Camp Pendleton is presently required to provide real time airspace release to the Federal Aviation Administration (FAA). Both systems appear to be capable of this function provided the required interface between FAA and Range Control were in place. In the heavily used airspace around Camp Pendleton, this system communication between the FAA and Range Control would help to ensure safety. Camp Pendleton personnel are working on this problem with the FAA and this issue is discussed in detail in the section entitled Future Considerations.

**14. Print special notes and instructions related to range, training, or airspace use entrees.**

Both systems perform very well when judged by this criterion.

**15. Prepare message responses to message-type range requests.**

**16. Prepare message range schedule and airspace releases.**

RFMSS has a feature to interface with word processing. Data can be imported into word processing software from RFMSS. Thereby, electrical messages can be prepared in the proper format with the required Optical

Character Recognition (OCR) font without re-keying any of the RFMSS data.

On the other hand, no such interface between the LUMS software and word processing software exists. Therefore, while LUMS will produce all the required information for these messages, that information must be re-keyed into a word processing system in order to produce the messages.

17. **Maintain data log for arrival/departure times, weapons used, ordnance type/amount used, number of personnel, number/type of equipment, altitude used.**

Both systems provide automated logs for this type of data. Type of equipment in the log in both systems provides only for the major type of equipment. For example, in both systems tanks would be shown but there are no log entry items for other equipment such as trucks, personnel carriers, etc. LUMS provides for the recording of this major equipment item in the main log. It is recorded in a local numeric data field in RFMSS. Number of personnel is recorded in the main log in LUMS; this number is also recorded in a local numeric data field in RFMSS.

18. **Maintain data for reports, by unit, training areas, weapons system, type ordnance, type training, amount requested versus amount used, and airspace released to the FAA by the time of day and altitude.**

Both systems maintain the data specified by this criterion with two exceptions. The first exception relates to the airspace released to the FAA by time of day and altitude. Neither system provides the data in this form. Both RFMSS and LUMS record the time of opening and closing of the range and the maximum altitude used. However neither system records whether the airspace was released to the FAA.

The second exception involves the type of ordnance. RFMSS tracks ordnance by type of rounds of type of

weapon. For instance, 20 rounds 81mm mortar, high explosive; 12 rounds 81mm mortar, white phosphorous; and 12 rounds of 81mm mortar, illumination would be recorded as stated in RFMSS. However, LUMS tracks ordnance only by type of weapon. Therefore, using the example above, LUMS would only record 44 rounds 81mm mortar.

**19. Schedule training devices and simulators.**

Both systems perform very well when judged by this criterion.

**20. Maintain a database of qualified range safety officers.**

RFMSS features a database for qualified range safety officers; LUMS does not.

**21. Display in color graphics a range use map showing maneuver, air, live-fire, and maintenance areas.**

Since LUMS is based on a GIS, it has this capability. However, Range Control personnel at Camp Lejeune where LUMS is operated seldom use this capability. RFMSS does not have this capability.

**22. Allow the master station to interface with another master station for range information via modem.**

RFMSS has the capability to interface master stations; LUMS does not.

**23. Allow for ready back-up of schedule data for access and retrieval in the event of primary media storage system failure.**
**24. Provide for manual scheduling operations in the vent of primary system failure.**
**25. Provide of manual operation because of primary system failure.**

These three criteria all relate to range scheduling operations in the event of a system failure. The proce-

dures for handling systems failure are largely a matter of local standing operating procedures (SOP). Both LUMS and RFMSS provide sufficient output to allow for manual operations until the system is restored.

**26. Provides user friendly operation.**

Both LUMS and RFMSS provide for user friendly operation. Both systems are menu driven with help features. Neither of the two systems requires operators to have much automatic data processing education or experience. The LUMS range scheduling system at Camp Lejeune is primarily operated by an E-6 armorer. The RFMSS system at Camp Pendleton is operated by infantry and artillery men under the supervision of an E-7 infantryman.

Neither system requires an increase in range control personnel, although one additional GS-9 programmer/ analyst is required for LUMS to operate the mini-computer and act as the database administrator for the GIS database. Range Control personnel operating RFMSS and LUMS felt that they were fully qualified to operate their respective range scheduling systems after one week of on-the-job training.

## WEIGHTING

In order to determine the relative benefit of each system, the analysis was narrowed. The thirteen criteria upon which both LUMS and RFMSS were judged to perform equally well were eliminated from consideration. The following criteria where either LUMS or RFMSS or both failed, or where system performance was less than optimal formed the basis for further benefit analysis.

1. Deconflict land and airspace use.
2. Allow flexibility in range designations and subdivision of training area.
3. Provide for changes in range boundaries and subdivisions.
4. Provide for changes to data or blocks of data.

5. Check to ensure that the weapon system and ordnance are authorized on the range requested.
6. Locate ranges or airspace for units to train in (the scheduler or unit would enter some of the parameters of the request, i.e., dates, times, type of training, amount of airspace required). The system would locate the area for the unit to train within the parameters of the request.
7. Schedule frequently used sets of ranges as a set or group.
8. Prepare message responses to message type range requests.
9. Prepare message range schedule and airspace release.
10. Provide reports on ammunition usage by type, e.g. 81mm HE, 81mm Illumination, 81mm WP.
11. Maintain database of qualified range safety officers.
12. Display in color graphics a range use map showing maneuver, air, live fire, and maintenance areas.
13. Allow the master station to interface with another master station for range information via modem.

Item 10 above stemmed from the original criterion:

- Maintain data log for arrival/departure times, weapons used, ordnance type/amount used, number of personnel, number/type of equipment, altitude used.

The ordnance/ammunition usage data by type were highlighted by MCCDC personnel as being the important aspect of this criterion since both systems performed equally when judged by each of the other aspects of this criterion.

The original thirteen criteria were revised into ten. Since the two criteria

- Prepare message responses to message-type range requests; and
- Prepare message range schedule and airspace releases

both relate to a message preparation capability, these two criteria were grouped as one. Additionally, since the three criteria

- Allow for flexibility in range designations and subdivision of training areas;
- Provide for changes in range boundaries and subdivisions; and
- Provide for changes to data in blocks of data

all relate to manipulation of a GIS database, these three criteria were grouped as one. Consequently, the original thirteen criteria were regrouped to form ten. These ten criteria were rank ordered by MCCDC as shown in the first column of Table 6.

The MCCDC ranking of these criteria produced three distinct subsets. The first subset consists of rank ordered criteria 1 and 2 which are safety related issues. The second subset consists of rank ordered criteria 3, 4, and 5 which are flexibility related issues. The third subset consists of rank ordered criteria 6 through 10 which are ease of administration issues. MCCDC personnel described that criteria within each of the three subsets were only marginally more important by rank. However, the importance across subsets differed greatly. Items in the flexibility subset were more than twice as important as the total of items in the administration subset. Items in the safety subset were more than twice as important as the total of all other criteria. Based on this description, the following weighting scheme was developed.

Rank order criterion 10 was assigned weight 1 and weight increased by 1 unit for each criterion in the administrative subset. The total weight of this subset is 15. Since criteria in the flexibility subset were to be more than twice as important as the total of the administrative subset. The first criterion in the flexibility subset was assigned a weight of 32 {(2x15)+2}. Higher ranked criteria in this subset were assigned values incremented by 2. The sum of the values of the administrative and flexibility subsets is 117. Criteria in the safety subset were to be more than twice as important as the total of all criteria of lesser rank. The first criterion in the safety subset was assigned a value of 238 {(2x117)+4}. The final criterion was then

assigned a weight of 242 incrementing by 4. These weights are shown in Table 6.

To compute the differential benefit of each system for each criterion, values were assigned to the degrees of performance on a uniform scale between 0 and 1. These values correspond to the Likert scale on the questionnaire as shown in Table 5. RFMSS was assigned values between 0 and 1 on two criteria. Because RFMSS partially solves the three-dimensional problem associated with deconflicting land and airspace use, RFMSS was assigned a value of 0.6 for this criterion, since system performance was deemed adequate. RFMSS was also assigned a value of 0.6 for the criterion -- Check to ensure that the weapon system and ordnance are authorized on the range requested. As discussed earlier, RFMSS provides for this check by range control personnel; whereas, LUMS performs this check and automatically rejects range requests where weapon system does not match weapon systems authorized for the range. Consequently, RFMSS performance was judged as adequate and the 0.6 value assigned.

| NO | YES | | | | |
|---|---|---|---|---|---|
| | DEGREE | | | | |
| | 1 | 2 | 3 | 4 | 5 |
| | Very Poorly | | Adequately | | Very Well |
| 0 | 0.2 | 0.4 | 0.6 | 0.8 | 1.0 |

Table 5
Performance Criterion Evaluation Scale

RFMSS was assigned a value of 0 for the criterion -- Schedule frequently used sets of ranges as a set or group. Although this capability is required by the specifications for RFMSS delivery version 2.2, this capability is not presently programmed and was not demonstrated.

To compute the benefit of each system, the system value was multiplied by the weight of each of the ten criteria and the results summed according to the following.

| BENEFIT ANALYSIS | | | | | | |
|---|---|---|---|---|---|---|
| RANK | CRITERION | WEIGHT | LUMS SYSTEM VALUE | RFMSS SYSTEM VALUE | LUMS BENEFIT | RFMSS BENEFIT |
| 1 | Deconflict land and airspace use. | 242 | 0 | 0.6 | 0 | 145.2 |
| 2 | Check to ensure that the weapon system and ordnance are authorized. | 238 | 1 | 0.6 | 238 | 142.8 |
| 3 | Locate ranges or airspace for units to train in (the scheduler or unit would enter some of the parameters of the request, i.e., dates, times, type of training, amount of airspace required). The system would locate an areas for the unit to train within the parameters of the request. | 36 | 0 | 0 | 0 | 0 |
| 4 | Allow the master station to interface with another master station for range information via modem. | 34 | 0 | 1 | 0 | 34 |
| 5 | Provide reports on ammunition usage by type, e.g. 81mm mortar HE, 81mm mortar illumination, 81mm mortar WP. | 32 | 0 | 1 | 0 | 32 |
| 6 | Schedule frequently used sets of ranges as a set or group. | 5 | 0 | 0 | 0 | 0 |
| 7 | Display in color graphics a range use map showing maneuver, air, live-fire, and maintenance areas. | 4 | 1 | 0 | 4 | 0 |
| 8 | Allow for flexibility in range designations and subdivision of training areas.<br>Provide for changes to range boundaries and subdivisions.<br>Provide for changes to data or blocks of data. | 3 | 1 | 0 | 3 | 0 |
| 9 | Prepare message responses to message-type range requests.<br>Prepare message range schedule and airspace releases. | 2 | 0 | 1 | 0 | 2 |
| 10 | Maintain a database of qualified range safety officers. | 1 | 0 | 1 | 0 | 1 |
| TOTAL SYSTEM BENEFIT | | | | | 245 | 357 |

**Table 6**
**Benefit Analysis**

$$S_j = \sum_{i=1}^{10} W_i V_{i,j}$$

Where:

$S_j$-System Benefit for each system j
$W_i$-Weight assigned for each criterion i
$V_{i,j}$-System value for criterion i for system j

From the Benefit Analysis, Table 6, a complete picture of the benefits can be seen. Of the ten rank ordered criteria, LUMS completely fails on seven of them; whereas, RFMSS completely fails on only four of the criteria. When the weight of each criterion and the associated systems value is taken into account, RFMSS scores 357 while LUMS scores 245. By forming the ratio of the total differential benefits of the two systems, RFMSS proves to be nearly one and one half times as effective as LUMS.

## SECONDARY CONSIDERATIONS

While the primary focus of the cost benefit analysis of LUMS and RFMSS is to compare them against established range scheduling criteria to determine which is the best system, there are secondary considerations that impact on the final decision of which system to recommend as the Marine Corps standard range scheduling system. These secondary considerations are: 1) interface of the range scheduling system with the Land and Training Area Requirements Management Information System (LATAR MIS), and 2) the interface of the range scheduling system and LATAR MIS with the Marine Corps Concepts, Doctrine, and Training (CONDOCTR) information system umbrella. No formal evaluation criteria are included in the cost benefit analysis that look at the interface of a range scheduling system and the LATAR MIS and CONDOCTR information umbrella. Thus the treatment of secondary considerations is descriptive rather than prescriptive and does not include costs.

LATAR MIS The intent of the LATAR MIS is to support analyses, programming and budgeting at Headquarters, United States Marine Corps, for training facilities, ranges, and maneu-

ver areas. The MIS will contain a requirements module, resources module, and modules to generate shortfalls (not enough range, maneuver or training facility resources) and deficiencies (ranges or maneuver areas do not meet established standards). An "alternatives" module will allow analysis of alternatives and/or fixes to overcome shortfalls and deficiencies.

In its simplest form, the LATAR MIS will allow a comparison of range/maneuver area/facility requirements with the corresponding resources. To do this function accurately requires that the LATAR MIS have a current inventory of ranges, maneuver areas and training facilities by location.

Both LUMS and RFMSS obviously must have an accurate inventory of range and maneuver areas by location. Thus there is an implicit interface between the LATAR MIS and the eventual Marine Corps standard range scheduling system. Should common Marine Corps standards be promulgated for ranges and maneuver areas, it is apparent that the LATAR MIS and the standard range scheduling system must be compatible in how they view deficient areas that do not meet standards.

There does not appear to be any reason why either LUMS or RFMSS cannot co-exist with the LATAR MIS. There is nothing in available documentation, Marine Corps Land and Training Area Requirements Study Final Report, September 1988, Installations and Logistics Department, Headquarters, United States Marine Corps, Washington, D.C., 20380-0001, to indicate that any explicit interface requirements have been considered between the LATAR MIS and an installation-level range scheduling system. Thus there is always the potential for inconsistent data between systems on resources, requirements, and possible alternatives and fixes to resolve shortfalls and deficiencies. Because of the additional complexity and cost to programmatically interface the LATAR MIS with a range scheduling system, it may be preferable to ensure administratively that conflicting data are not generated.

In an area not directly related to the LATAR MIS interface consideration, it is interesting to note that the proposed LATAR MIS database structure does not appear to include information on range, maneuver area, or training facility utilization. While it is necessary for the LATAR MIS to generate range/area/facility resource requirements based on

forecast load, it would also be useful, if not necessary, to know what the utilization of ranges, maneuver areas, and training facilities has been. In many instances, requirements tend to be inflated while actual utilization is a more accurate way to portray resource constraints. Especially when additional resources are being requested, the actual utilization of existing resources is always questioned. Thus, it would seem that the LATAR MIS should have an interface designed to hold actual range and maneuver area utilization as recorded in a range scheduling system. Either LUMS or RFMSS appear to be able to supply utilization data.

CONDOCTR CONDOCTR (Concepts, Doctrine, Training) is a data architecture and information system application designed to allow MCCDC offices at Quantico to access any of the information systems that carry concepts, doctrine, or training data. CONDOCTR is designed to improve the compatibility, access, and flow of information between various databases and information systems that support concept and doctrine development and analysis of the impact on training requirements, methods and resources.

As a top-level application program allowing access to disparate information systems, CONDOCTR must necessarily be flexible in its design and development approach. Thus it would not appear that the particular characteristics of either system should prevent a problem for interface with CONDOCTR. The more probable scenario is that the installation range scheduling system should interface with the LATAR MIS, which in turn would interface with CONDOCTR.

Summary. From available documentation, it does not appear that either the LATAR MIS or CONDOCTR has explicit provisions for interfacing with an installation level range scheduling system. It does appear that administrative controls would be needed to ensure that compatible data are produced among the systems. It also appears that the LATAR MIS (and perhaps CONDOCTR) should have an interface that captures utilization data from whatever range scheduling system becomes the standard.

# IX. COST/BENEFIT ANALYSIS

To complete the analysis of RFMSS and LUMS, cost benefit ratios relating costs to benefits are analyzed. Additionally, the sensitivity of the results of the cost benefit ratios to changes in weighting scheme are analyzed.

## COST/BENEFIT RATIOS

Marginal costs were computed in Section VII. The present values per site of those marginal costs were $447,814 for LUMS per site and $88,840 for RFMSS. The weighted benefits were computed in Section VIII. The weighted benefits were 245 for LUMS and 357 for RFMSS. To relate costs and benefits the ratios of cost to benefit were computed as follows.

Cost/Benefit Ratio (LUMS) = 447,814/245 = 1,827.81

Cost/Benefit Ratio (RFMSS) = 88,840/357 = 248.85

As seen by comparing these ratios, RFMSS is more than seven times as effective than LUMS from a cost/benefit perspective over the twelve-year life cycle. Therefore, RFMSS is the recommended alternative from a cost/benefit perspective.

## SENSITIVITY ANALYSIS

Two methods of analyzing the sensitivity of the solution that RFMSS is the preferred system from a cost/benefit perspective are presented below.

Method 1 If an extreme assumption is made that LUMS could be enhanced with all the capabilities that it now lacks at no additional cost, then a new total benefit of 597 (as opposed to the total benefit of 245) would be assigned to LUMS. (refer to Table 6) The following new ratio would result:

Cost Benefit Ratio
(LUMS enhanced) = 447,817/597 = 750.11

Cost Benefit Ratio (RFMSS) = 88,840/357 = 248.85

The solution is not sensitive to this extreme assumption, as RFMSS would still be the more effective from a cost benefit perspective than an enhanced LUMS by a wide margin.

Method 2 A second method to analyze the sensitivity of this solution boils down to the question of "What changes would be required in the weighting scheme in order for both LUMS and RFMSS to be equally effective in terms of cost/benefit ratios?" To answer this question requires a review of the basic difference between the two systems. That difference is that LUMS is based on a Geographic Information System (GIS) whereas RFMSS has no GIS.

LUMS having a GIS relates directly to two of the ten grouped criteria:

1. • Display in color graphics a range use map showing maneuver, air, live fire, and maintenance areas.

2. • Allow flexibility in range designations and subdivision or training area.
   • Provide for changes in range boundaries and subdivisions.
   • Provide for changes to data or blocks of data.

If these two criteria were removed from the initial ranking and weighting scheme and reranked numbers 1 and 2 and the criteria were reweighted using a similar scheme as described in Section VII, the ranks and weights shown in Table 7 would result.

The new groupings would result in four subsets. Subset one consists of the newly ranked items 8 through 10 relating to administration. Subset two consists of newly ranked items 5 through 7 relating to flexibility. Subset 3 consists of newly ranked items 3 and 4 relating to safety. Subset 4 consists of newly ranked items 1 and 2 relating to GIS. Items 1 and 2 have been assigned a weight of X. The solution for the weight X will be used to answer the sensitivity question posed in the beginning of this section.

| SENSITIVITY ANALYSIS - METHOD 2 | | | | | | |
|---|---|---|---|---|---|---|
| RANK | CRITERION | WEIGHT | LUMS SYSTEM VALUE | RFMSS SYSTEM VALUE | LUMS BENEFIT | RFMSS BENEFIT |
| 1 | Display in color graphics a range use map showing maneuver, air, live-fire, and maintenance areas. | | | | | |
| 2 | Allow for flexibility in range designations and subdivision of training areas.<br>Provide for changes to range boundaries and subdivisions.<br>Provide for changes to data or blocks of data. | X | 1 | 0 | X | 0 |
| 3 | Deconflict land and airspace use. | 80 | 0 | 0.6 | 0 | 48 |
| 4 | Check to ensure that the weapon system and ordnance are authorized. | 76 | 1 | 0.6 | 76 | 45.6 |
| 5 | Locate ranges or airspace for units to train in (the scheduler or unit would enter some of the parameters of the request, i.e., dates, times, type of training, amount of airspace required). The system would locate an areas for the unit to train within the parameters of the request. | 12 | 0 | 0 | 0 | 0 |
| 6 | Allow the master station to interface with another master station for range information via modem. | 10 | 0 | 1 | 0 | 10 |
| 7 | Provide reports on ammunition usage by type, e.g. 81mm mortar HE, 81mm mortar illumination, 81mm morter WP. | 8 | 0 | 1 | 0 | 8 |
| 8 | Schedule frequently used sets of ranges as a set or group. | 3 | 0 | 0 | 0 | 0 |
| 9 | Prepare message responses to message-type range requests.<br>Prepare message range schedule and airspace releases. | 2 | 0 | 1 | 0 | 2 |
| 10 | Maintain a database of qualified range safety officers. | 1 | 0 | 1 | 0 | 1 |
| TOTAL SYSTEM BENEFIT | | | | | 76+X | 114.6 |

**Table 7**
**Sensitivity Analysis -- Method 2**

Following the same procedure discussed in Section VII, a new Benefit Value Analysis table – Table 7 – was constructed using the new weights and same systems values as shown in Table 6.

These new total benefits values are used to compute new cost benefit ratios as follows.

$$\text{Cost/Benefit Ratio (LUMS)} = 447{,}817/(76+X)$$

$$\text{Cost/Benefit Ratio (RFMSS)} = 88{,}840/114.6$$

When these new differential cost/benefit ratios are set equal, a value for X can be calculated. That value is 501.67, as compared to the total value of 192 for newly ranked items 3-10. Therefore, in order to produce equivalent cost/benefit ratios, the combination of newly ranked items 1 and 2 would have to be deemed two and one half times more important than the combination of the other eight criteria. Only if the GIS aspect approaches this degree of importance is the selection of RFMSS affected.

## X. OTHER CONSIDERATIONS

In addition to evaluation of costs, identified benefits, and secondary considerations, there are several other items to consider. These include RFMSS enhanced with graphic display, LUMS developed for networked PC operation, and other future considerations.

### RFMSS ENHANCED

Presently, RFMSS does not have a graphic display capability to show a map of the training and impact areas. To enhance RFMSS with a full GIS database would require additional hardware and software elevating costs into the range of LUMS. Additionally, one-time system development costs would be incurred so that costs of this option would probably exceed those allocated to LUMS. Consequently a GIS enhanced RFMSS is not a viable solution.

CERL is presently working on a graphic display capability for RFMSS. This display capability is not based on GIS and this prototype runs on the present networked PCs hardware configuration. The prototype displays ranges, training areas, and impact areas. Ranges and training areas are identified by different shaped icons. The color of each icon identifies the range/training area status, e.g. occupied, live-fire, check-fire, etc. By selecting the icon and zooming in (by mouse or touch screen) additional information in the range/training area is identified. CERL estimates that this enhancement will be available in FY91.

This enhancement for RFMSS provides for a partial solution to one of the criteria that RFMSS failed -- display in color graphics a range use map showing maneuver, air, live-fire, and maintenance areas. This RFMSS enhanced solution does not provide for full boundary mapping that LUMS does. This solution will be provided to RFMSS users on a no/low cost basis.

## LUMS MINUS GIS

Due to the high cost of the GIS-based LUMS, an alternative of separating the range scheduling programming from the mini-computer system should be addressed. It may be possible to separate the range scheduling programming from LUMS and run it on networked PCs. The program development costs for such reprogramming are estimated to be approximately $100,000 to 200,000. The resulting system could be run on a software configuration similar to the one that was the cost basis for RFMSS. By eliminating the mini-computer and GIS database and software, the LUMS cost of the programmer/analyst would also be saved. Overall, then LUMS minus GIS would result in greatly reduced costs when compared with the present LUMS with GIS. For hardware and software, the cost of this option would probably approach the hardware and software costs of RFMSS. However, the resulting system would be less effective than the present LUMS system as the new system would lose the following capabilities associated with a GIS based system:

- Display in color graphics a range use map showing maneuver, air, live fire, and maintenance areas.

- Allow flexibility in range designations and subdivision of training areas.
- Provide for changes in range boundaries and subdivisions.
- Provide for changes to data or blocks of data.

The net result of this option would be a more costly (development costs) and less effective (loss of capability) system than RFMSS. Consequently, LUMS minus GIS is not a viable alternative.

**OTHER CONSIDERATIONS**

Camp Pendleton personnel are working on an interface between Federal Aviation Administration (FAA) radar and RFMSS. This interface will provide digitized radar data to RFMSS for tracking aircraft within designated airspace. Details and interfaces must be worked out over the next year; however, initial feasibility estimates are positive. This feature will greatly enhance the safety capabilities of RFMSS.

## XI. RECOMMENDATIONS

A. RFMSS should be selected as the Marine Corps Range Scheduling System. RFMSS is the better system when compared to LUMS from the perspective of cost, benefits, and combined cost/benefit ratios.

B. A comprehensive site analysis should be conducted at each of the six expansion sites. As stated in the cost section of this study, cost data are based on a worst case scenario. The site analysis will identify the precise costs for each site and identify problems unique to each site.

# APPENDIX A

# REFERENCES

## APPENDIX A

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# APPENDIX B

# RANGE SCHEDULING SYSTEM CRITERIA

# APPENDIX B
# RANGE SCHEDULING SYSTEM CRITERIA

| Allocation and Scheduling | YES Degree | | | | | NO |
|---|---|---|---|---|---|---|
| | 1 Very Poorly | 2 | 3 Adequately | 4 | 5 Very Well | |
| Allow the local range management office to act as the master scheduling authority receiving, consolidating, deconflicting and issuing range requests from multiple users via desk top terminals. | | | | | | |
| Deconflict training areas. | | | | | | |
| Deconflict land and airspace use. | | | | | | |
| Allow for flexibility in range designations and subdivision of training areas. | | | | | | |
| Provide for changes to range boundaries and subdivisions | | | | | | |
| Check to ensure that the weapon system and ordnance are authorized on the range requested. | | | | | | |
| Locate ranges or airspace for units to train in (the scheduler or unit would enter some of the parameters of the request, i.e., dates, times, type of training, amount of airspace required). The system would locate an area for the unit to train within the parameters of the request. | | | | | | |
| Schedule frequently used sets of ranges as a set or group. | | | | | | |

RANGE SCHEDULING SYSTEM CRITERIA (Cont'd)

| Messages, Reports and Status Information | YES Degree | | | | | NO |
|---|---|---|---|---|---|---|
| | 1 Very Poorly | 2 | 3 Adequately | 4 | 5 Very Well | |
| Display current status of range, i.e. empty, occupied live- fire, non live-fire, overflight live-fire, overflight non live-fire. | | | | | | |
| Display unit status on range, i.e., non live-fire and live-fire. | | | | | | |
| Print a range training area schedule. | | | | | | |
| Compute and print the airspace release. | | | | | | |
| Print special notes and instructions related to range, training, or airspace use entrees. | | | | | | |
| Maintain data for reports, by unit, training areas, weapons system, type ordnance, type training, amount requested versus amount used, and airspace released to the FAA by the time of day and altitude. | | | | | | |
| Prepare message responses to message-type range requests. | | | | | | |
| Prepare message range schedule and airspace releases. | | | | | | |

RANGE SCHEDULING SYSTEM CRITERIA (Cont'd)

| Software/Hardware Considerations | YES Degree | | | | | NO |
|---|---|---|---|---|---|---|
| | 1 Very Poorly | 2 | 3 Adequately | 4 | 5 Very Well | |
| Provide for changes to data or blocks of data. | | | | | | |
| Display in color graphics a range use map showing maneuver, air, live-fire, and maintenance areas. | | | | | | |
| Allow the master station to interface with another master station for range information via modem. | | | | | | |
| Allow for ready back-up of schedule data for access and retrieval in the event of primary media storage system failure. | | | | | | |
| Provide for manual scheduling operation in the event of primary system failure. | | | | | | |
| Provide of manual operation because of primary system failure. | | | | | | |
| Provides user friendly operation. | | | | | | |
| **Ancillary Databases and Functions** | | | | | | |
| Schedule training devices and simulators. | | | | | | |
| Maintain a database of qualified range safety officers. | | | | | | |
| Maintain data log for arrival/departure times, weapons used, ordnance type/amount used, number of personnel, number/type of equipment, altitude used. | | | | | | |

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